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1. Your reference	RSJ07636GB	
2. Patent application number *(The Patent Office will fill in this part)*	27 NOV 2002	0227686.3
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	City Technology Limited City Technology Centre Walton Road, Portsmouth Hants, PO6 1SZ Great Britain	
Patents ADP number *(if you know it)*		6217830001
If the applicant is a corporate body, give the country/state of its incorporation	Great Britain	
4. Title of the invention	GAS SENSING DEVICE	
5. Name of your agent *(if you have one)*	Gill Jennings & Every	
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Broadgate House 7 Eldon Street London EC2M 7LH	
Patents ADP number *(if you know it)*	745002	

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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Description	12
Claim(s)	3
Abstract	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	NO

11. For the applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date
27 November 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

R.E. Skone James
020 7377 1377

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GAS SENSING DEVICE

This invention relates to a device for sensing a gas, in particular a flammable gas, in air.

Catalytic oxidation is a well established and often used method for detecting flammable gases in which an element is heated in order to oxidise any flammable gas present. During oxidation, heat is evolved which causes the temperature of the element to rise and results in an increase in its electrical resistance which may be detected to indicate the presence of a flammable gas. Typically, the element comprises a filament of thin metal wire on which a porous bead is formed which includes a catalyst. Commonly, one such element is used in conjunction with a second, of similar construction but catalytically inactive, in a Wheatstone bridge circuit. Thus the inert element may act as a control, compensating for variations in ambient temperature. To ensure combustion of the flammable gas, the elements must be operated at an elevated temperature, of the order of 500°C.

To ensure safe operation of such a device, the elements must be enclosed within a housing which prevents gas outside the device being ignited by the gas undergoing combustion inside. However in order for the device to function, gas must be able to flow into the enclosure. This is achieved by the inclusion of a flame arrestor in the housing, such as a metal mesh or a sinter element, through which gas may enter the device yet an ignition source may not escape.

Certain regulations must be met by the housing in order for it to be certified as flameproof and capable of withstanding the rapid and significant changes which can arise on combustion of the flammable gas inside the device. These changes may be in terms of pressure, temperature, chemical composition etc. All in all, the device must not allow ignition of the external gas mixture, irrespective of

the conditions inside the device. This is achieved by a number of precautions, including:

the use of a flame arrestor to conduct heat away sufficiently rapidly that a flame cannot propagate through this component;

ensuring that the strength of the housing materials and design is sufficient to prevent rupturing as a result of extreme conditions inside; and

confirming that any gas expelled from the sensor has insufficient energy to cause an external ignition, for example by limiting its exit rate and temperature.

In virtually all cases, it is necessary to provide the device with components which must pass through the housing wall, for example electrical connectors. This results in gaps between the housing and the protruding component(s) which could allow ignited gas to escape. In such a situation, the device must be provided with one or more layers of potting compound, cement or other encapsulant which serve to seal the gaps and complete the flameproof enclosure. At present, there are regulations which specify the minimum thickness of such layers. In the UK, the potting compound typically has a minimum thickness of 3 mm.

The result is a final device size which is significantly larger than the volume required by the operational components alone. It would be advantageous to reduce the size of the final product, and in particular reduce it from a 3 dimensional object to a substantially flat device. This would lead to possible new uses of such a gas sensor, such as a clip-on badge sensor which could be worn by workers in a potentially dangerous industrial situation, for example.

The majority of known flameproof housings are cast from metal and require several millimetres of potting compound and flame arrestor material, as well as impact protection for the flame arrestor in order fully to meet the relevant safety and performance standards. EP-A-0667519 achieves a small reduction in device size by

mounting the gas sensitive elements onto a track carrying substrate such that they may be contained within the thickness of a typical PCB. However, the remainder of the device is largely conventional and hence the final size is not significantly reduced.

GB-B-2328508 describes a method of joining the flame arrestor to the housing which overcomes the need for precision machining and accelerates the fixing operation whilst producing a join which is certifiably flameproof. The invention makes use of a plastics housing which is moulded in situ around the flame arrestor, which is in the form of a metal sinter material. This does not however address the issue of device size.

In accordance with the present invention a device for sensing a gas comprises at least one gas sensitive element contained within a flameproof, plastics housing supporting a flame arrestor which enables gas to flow into the interior of the housing, and the gas sensitive element(s) being connected to conducting leads which extend through, and are encapsulated by, the wall of the housing, the encapsulating wall having sufficient thickness such that the housing will not allow the propagation of an ignition source from within the device to the ambient atmosphere, under working conditions.

The invention further provides a method of manufacturing a device for sensing a gas, the method comprising moulding a plastics housing in situ directly around a set of conducting leads, mounting at least one gas sensitive element inside the housing and connecting it or them to the conducting leads which extend through, and are encapsulated by, the wall of the housing, the encapsulating wall having sufficient thickness that the housing will not allow the propagation of an ignition source from within the device to the ambient atmosphere, under working conditions, and securing a flame arrestor to the housing which completes the flameproof enclosure yet enables gas to flow into the interior.

The present invention eliminates the requirement for a layer of potting compound. By encapsulating a sufficient length of the conducting leads in the plastic wall by which we mean that there is intimate contact between the wall and the conducting leads, there is no gap at the metal/plastic interface which could allow ignited gas or another such ignition source to escape the flameproof enclosure. Therefore a significant size reduction is possible and a substantially flat device may be constructed. In particular, by enabling the use of electrically insulating (plastic) materials for the enclosure around the electrical connectors, a whole new range of design freedoms are made possible. Previous inventions such as GB-B-2328508 have not recognised such materials as suitable to fulfil this role. One key benefit of the present invention is the ability to arrange that encapsulation occurs in the horizontal plane rather than in a vertical direction as would usually be the case for a practical, compact, potted device.

Preferably, the plastics housing is fabricated by moulding in situ the plastics material directly around the conducting leads. This method not only produces a flameproof seal between the conducting leads and the housing but also simplifies the assembly process, being ~~less expensive and more easily controllable than~~ traditional methods of incorporating electrical connections through the housing wall, which involve potting. Potting requires liquid handling and pouring, and the potting material may undergo contraction during solidification which must be compensated for by making the layer thicker than would otherwise be necessary. It is therefore highly advantageous to form a flameproof seal in one moulding step, without the need for potting.

Preferably, the device further comprises at least one filter in order to remove contaminants from the gas flow into the device. Certain substances may have a detrimental effect on the operation of the device should they reach the

gas sensitive elements, and should therefore be removed by appropriate filters. Generally, at least one filter is provided which removes hydrogen sulphide from the gas flow into the device. Typically, at least one of the filter(s) are inboard of the flame arrestor. This provides some degree of protection and holds them in place without the need for further fixings. However filters may also be located outboard of the flame arrestor, possibly held in place by at least one clip.

The device preferably further comprises means for protecting one or more of the gas sensitive element(s) from shock damage. This aims to minimise damage should the device suffer mechanical shock. Generally, the device further comprises means for insulating the gas sensitive element(s) and electrical connections, either in terms of electrical insulation or heat insulation, or both. Preferably, the protecting and/or insulating means comprise at least one layer of shock absorbent and insulating material. The two functions may be carried out by the same material, provided it is inert, has suitable mechanical properties and low heat conductance. Typically, the shock absorbent and/or insulating material is glass wool.

Preferably, the flame arrestor is provided by a metal mesh. This is an advantageous alternative to using a sintered metal powder, since an equivalent flameproof standard may be achieved using a thinner section. Generally, the flame arrestor is joined to the plastics housing by a process of thermal bonding around its perimeter. This is achieved by applying pressure to the periphery via a hot workpiece, and results in a flameproof bond between the flame arrestor and the housing, by means of plastic flow into the voids in the metal mesh.

Typically, the device comprises two gas sensitive elements wherein one is a detecting element and the other is a compensating element, which behaves similarly except in its response to the gas. When the device is connected to detector circuitry, the two elements form part of a

Wheatstone bridge circuit which provides a signal proportional to the gas concentration. Generally, the detecting element comprises a catalytic bead, such as a pellistor. The compensating element is catalytically inactive. However, the detecting element could also comprise a micromachined or planar pellistor or other types of heated gas sensor, for example semiconductor sensors or those which rely on thermal conductivity to detect gas.

Preferably, each gas sensitive element is positioned at least partly within a recess in an interior wall of the housing. Also preferably, each recess also contains means for the protection and insulation of the gas sensitive element positioned at least partly inside it. This provides further protection against impact damage and reduces heat loss from the gas sensitive elements.

The thickness of the portion of the housing wall through which the conducting leads extend is usually substantially at least 6 mm. The length of encapsulation of the conducting leads will be chosen to meet the safety requirements for flameproof certification, which may change in due course as standards evolve.

Although the encapsulation length may be longer than with conventional potted devices, there is greatly increased design freedom. For example, typically, the flame arrestor is located above the gas sensitive element(s), the conducting leads extending out through a side wall of the housing. This has the advantage of making it possible to construct a substantially flat device.

Preferably, the conducting leads are coupled with respective contacts located in an integral extension of the housing. This configuration enables the device to be connected to other electrical components in a variety of ways, as may be chosen to suit each respective application.

Conveniently, the conducting leads are provided by a metal lead frame fabricated prior to encapsulation by the plastics housing. By "lead frame", we refer to a conducting portion of the device, rather than to a frame

made out of lead (Pb). This enables straightforward moulding of the plastics housing directly around the metal, and is more convenient than incorporating more than one component during the moulding process.

In the preferred example, the housing is formed by moulding the plastics material around the lead frame and subsequently mounting the other components. However in some situations it may be more appropriate to mould the housing around more of the components, in situ. For example, the gas sensitive element(s) could be connected to the lead frame before the housing is moulded.

Preferably, the device further comprises means for retaining components located outboard of the flame arrestor. Typically, the retaining means is provided by a bezel which fastens mechanically to the housing. The bezel also provides some degree of mechanical protection for the flame arrestor and filter(s).

An example of a gas sensor incorporating a device for sensing a gas in accordance with the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows an exploded view of a gas sensing device;

Figure 2 is a schematic plan view of the housing, gas sensitive elements and conducting leads as shown in Figure 1 but with the conducting leads extending out of the housing;

Figure 2A is a schematic underneath plan showing projections of the uppermost features of the devices as dashed lines, the location of the lead frame in solid lines and shortest distances along the conducting path, though the wall of the housing in bold;

Figure 3 is an underneath plan of the device as shown in Figure 1;

Figure 4 is a section taken on the line A - A in Figure 2, but illustrates a complete device with the exception of the metal bezel 14;

Figure 5 comprises Figures 5a and 5b which show, respectively, a plan and a side view of a conducting lead frame before the housing has been moulded around it; and,

Figure 6 is a circuit diagram of a detecting circuit attached to the device.

The gas sensing device shown in Figures 1 to 4 comprises a plastics housing 1, made from a material such as PEI (polyetherimide), PPS (polyphenylsulphide) or PTFE for example, moulded around a metal lead frame 2, which is shown in more detail in Figure 5. The housing includes a wall 10 which surrounds a cavity, at the base of which is a substantially square recess 12 which itself is surrounded by a raised, ridged shelf 11 which is substantially circular. In the floor of the recess 12 are two further recesses 13 containing glass wool 9 which acts as a shock absorber and insulator.

Mounted in the housing 1 are two conventional pellistor gas sensing elements: a detector 4 and a compensator 5. Each element comprises a metal filament encased by a porous bead, the detector element 4 including also a catalyst which may be chosen according to the gas which is to be detected. The elements 4 and 5 are connected to the lead frame 2 by means of conducting cement or welding, for example. The metal leads are encapsulated ~~by the wall of the housing 10 and exit the housing body as~~ tabs 22-24 as shown in Figures 2 and 3, although in other examples they may not extend through the apertures 18 - 20 as shown in Figure 1.

A second layer of glass wool 8 is located above the gas sensitive elements 4 and 5, inside the recess 12. A hydrogen sulphide filter 7 rests on the housing floor 11a above the recess 12. The H_2S filter 7 is typically fabricated using a paper or glass wool filter impregnated with lead acetate and as such it is desirable that it is inboard of the flame arrestor 3 to prevent users from coming into contact with it. An enclosure is created by the joining of the metal mesh flame arrestor 3 to the top

of the shelf 11, which is sufficiently wide to ensure that the resulting joint is at least 1.25mm wide. The mesh 3 allows the passage of gas into the cavity yet acts as a flame arrestor and thus renders the enclosure flameproof. A second, silica filter 6 is located on the outboard side of the flame arrestor 3 and comprises a glass fibre disc coated with 25% Si.. Its purpose is to absorb chronic, irreversible pellistor catalyst poisons such as the silicone HMDS. The two filters 6 and 7 together remove contaminants from the gas flow into the device. It is also envisaged that plural filters such as 6 and 7 could be combined into a single, multi-purpose filter, although this is not shown in the drawings.

A metal bezel 14 clips onto the housing 1 in order to hold components such as filter 6 in place and to provide the device with protection. The bezel 14 is provided with a number of holes 16 which enable the bezel 14 to be fastened to the housing 1 by means of a corresponding number of barbs 17 on the housing exterior. The bezel 14 also incorporates one or more holes 15 through which gas may enter the device.

The features of the housing 1 are shown in plan view in Figure 2. The dashed lines indicate the position of the lead frame 2. The gas sensitive elements 4 and 5 are connected to the lead frame 2 which emerges from the housing as leads 22 - 24, through apertures 18 - 20. At least 6 mm of each conducting lead is encapsulated by the wall of the housing 1. Figure 2A illustrates the shortest path on each of the three conducting lines which pass through the housing to connect the gas sensitive elements inside the flameproof enclosure to the detecting circuit outside. It is clear that the path marked "Y" is the shortest path and it is this path therefore which requires most scrutiny by the certifying authorities. Generally path "Y" must be at least 6mm long. The lead frame 2 also comprises a trimming resistor 21 which is connected between

the leads 23 and 24 and is present to compensate for differences in performance of the two elements 4 and 5.

Figure 3 shows that the same leads 22 - 24 may be also accessed from beneath the device, through apertures 25 - 27 respectively, which are formed in an integral, lateral extension of the housing 1. This may be useful, for example, when mounting the device onto a printed circuit board (PCB). Again, the lead frame 2 is represented inside the housing by dashed lines. The circles L, seen also in Figures 1 and 2 are a result of the use of lead frame locating pins during the moulding process.

The arrangement of the layers can be seen most clearly in Figure 4. The gas sensitive elements 4 and 5 are shown to be sandwiched between layers of glass wool 8 and 9 which provide protection from mechanical shock, electrical insulation and insulation from heat loss. In a typical arrangement, the depth of the recess 13 over which the element 4 or 5 is located is approximately 0.5 mm and its diameter 2 mm. The recess 12 above the gas sensitive elements is generally about 1 mm deep and 5 mm by 5 mm in area. The device has a total height of approximately 4mm.

The all-metal lead frame 2 is shown in more detail in Figure 5, prior to its encapsulation by the plastics housing 1. Once the housing 1 has been moulded around the lead frame 2, the metal is cut along line 34 to separate the conducting leads. This line need not coincide with the outer edge of the plastics housing and in particular conducting leads may be left protruding from the housing, as shown in Figures 2 and 3. It is envisaged that the lead frame is constructed from beryllium copper, with a hard acid gold plating layer, substantially 0.5 microns in thickness, over electroless nickel. However, any number of other variants could in principle satisfy the same requirements of good mechanical stability, resistance to degradation caused by aggressive operational environments and good electrical conductivity. It would also be possible to have a lead frame 2 in the form of a pre-

moulded subassembly, in which the joining part 35 is an insulating material and may therefore remain attached, for example to assist in placing the device into an instrument. As shown in Figure 5b, the lead frame 2 need not be flat. In the example shown, most of the interior portion of the lead frame 2 is raised slightly with respect to the exterior parts.

The detector element 4 is connected between points 28 and 29 on the lead frame 2, and the compensator element 5 between points 30 and 31 by means of conducting cement or welding, for example. The trimming resistor 21 joins points 32 and 33. Layers 8 and 9 of glass wool are packed above and below the elements 4 and 5 and a filter 7 is positioned on the housing floor, on top of the glass wool 8. The flame arrestor 3 is joined around its perimeter to the top of the shelf 11 of the housing 1 by means of a thermal bonding process such as heat staking. Filter 6 is then located on the outboard side of the flame arrestor, and held in place by the metal bezel 14, which is mechanically fastened to the housing by means of barbs 17 and holes 16. In use, gas passes though the bezel 14, the flame arrestor 3, both filters 6 and 7 and at least one layer of glass wool 8 to reach the detecting element 4.

Figure 6 is a circuit diagram to illustrate a Wheatstone bridge circuit which incorporates the two elements 4 and 5. As described above, the elements are coupled to leads 22 - 24, with a trimming resistor 21 between leads 23 and 24. The lead 24 forms one output 36 of the circuit directly. Leads 22 and 23 are joined to resistors R1 and R2 at points 37 and 38 respectively. Resistors R1 and R2 are connected at point 39 to a variable resistor 40. Point 39 also provides the second output 41. DC power is supplied to the circuit at 42, and is used to heat the elements 4 and 5 to their working temperature of approximately 500°C as well as to power the circuit. However, it should be noted that the sensors could also be

operated in circuits other than the Wheatstone bridge described above.

CLAIMS

1. A device for sensing a gas, the device comprising at least one gas sensitive element contained within a flameproof, plastics housing supporting a flame arrestor which enables gas to flow into the interior of the housing, and the gas sensitive element(s) being connected to conducting leads which extend through, and are encapsulated by, the wall of the housing, the encapsulating wall having sufficient thickness such that the housing will not allow the propagation of an ignition source from within the device to the ambient atmosphere, under working conditions.

2. A device according to claim 1 wherein the plastics housing is fabricated by moulding in situ the plastics material directly around the conducting leads.

3. A device according to claim 1 or claim 2 further comprising at least one filter in order to remove contaminants from the gas flow into the device.

4. A device according to claim 3 wherein the filter, or at least one of the filters, removes hydrogen sulphide from the gas flow into the device.

5. A device according to claim 3 or claim 4 wherein at least one of the filter(s) is inboard of the flame arrestor.

6. A device according to any of the preceding claims further comprising means for protecting one or more of the gas sensitive element(s) from shock damage.

7. A device according to any of the preceding claims further comprising means for insulating the gas sensitive element(s) and electrical connections, either in terms of electrical insulation or heat insulation, or both.

8. A device according to claims 6 and 7 wherein the protecting and/or insulating means comprise at least one layer of shock absorbent and insulating material.

9. A device according to any of claims 6 to 8 wherein the shock absorbent and/or insulating material is glass wool.

10. A device according to any of the preceding claims wherein the flame arrestor is a metal mesh.

11. A device according to any of the preceding claims wherein the flame arrestor is joined to the plastics housing by a process of thermal bonding around its perimeter.

12. A device according to any of the preceding claims comprising two gas sensitive elements wherein one is a detecting element and the other is a compensating element.

13. A device according to claim 12 wherein the detecting element comprises a catalytic bead.

14. A device according to any of the preceding claims wherein each gas sensitive element is positioned at least partly within a recess in an interior wall of the housing.

15. A device according to claim 14 wherein each recess also contains means for the protection and insulation of the gas sensitive element positioned at least partly inside it.

16. A device according to any of the preceding claims wherein the thickness of the portion of the housing wall through which the conducting leads extend is substantially at least 6 mm.

17. A device according to any of the preceding claims wherein the flame arrestor is located above the gas sensitive element(s), the conducting leads extending out through a side wall of the housing.

18. A device according to claim 17 wherein the conducting leads are coupled with respective contacts located in an integral extension of the housing.

19. A device according to any of the preceding claims wherein the conducting leads are provided by a metal lead frame fabricated prior to encapsulation by the plastics housing.

20. A device according to at least claim 3 which further comprises means for retaining components located outboard of the flame arrestor.

21. A device according to claim 20 wherein the retaining means is provided by a bezel which fastens mechanically to the housing.

22. A method of manufacturing a device for sensing a gas, the method comprising moulding a plastics housing in situ directly around a set of conducting leads, mounting at least one gas sensitive element inside the housing and connecting it or them to the conducting leads which extend through, and are encapsulated by, the wall of the housing, the encapsulating wall having sufficient thickness that the housing will not allow the propagation of an ignition source from within the device to the ambient atmosphere, under working conditions, and securing a flame arrestor to the housing which completes the flameproof enclosure yet enables gas to flow into the interior.

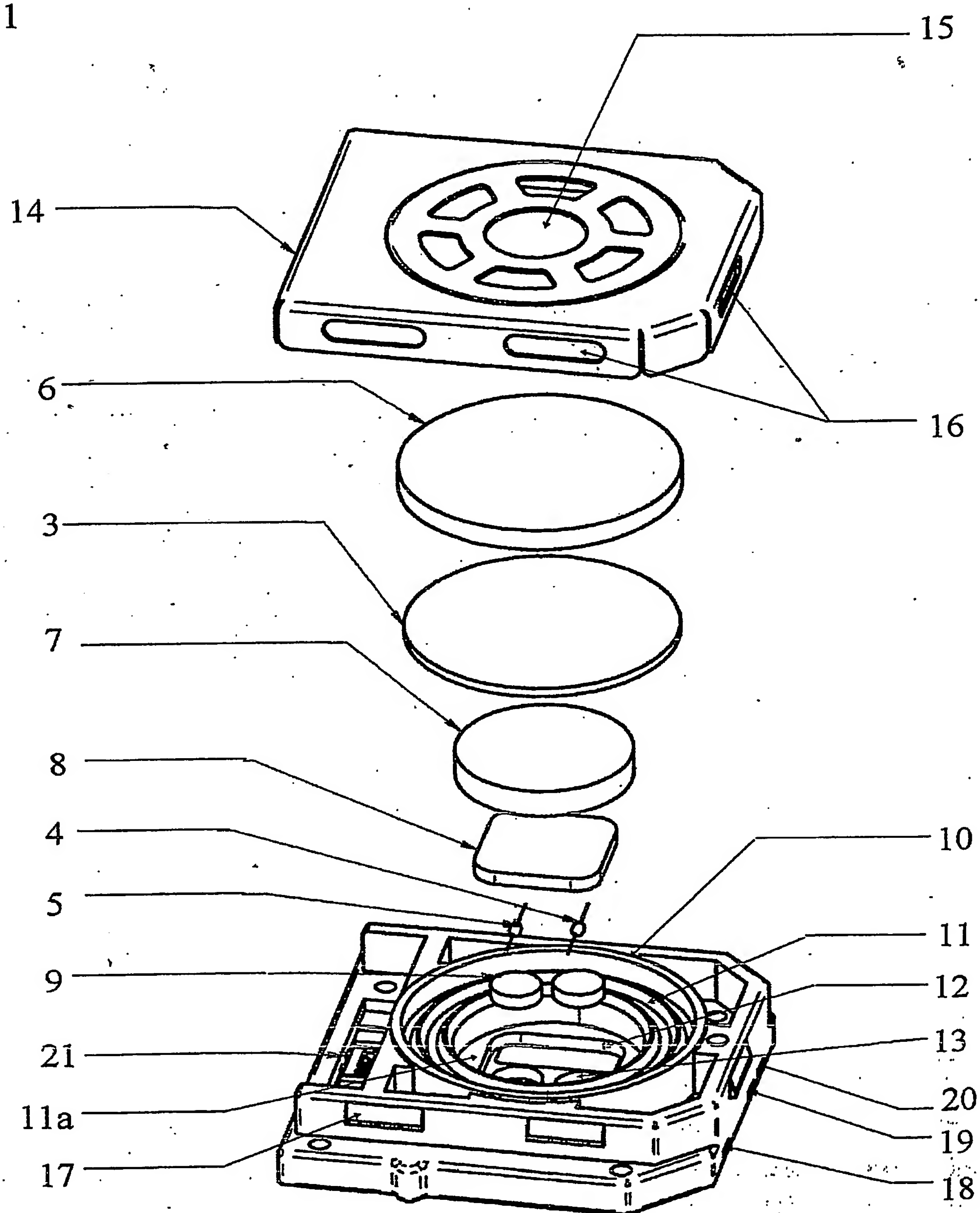
23. A method according to claim 22 wherein the flame arrestor is joined to the plastics housing by a process of thermal bonding around its perimeter.

24. A method according to claim 22 or claim 23 for constructing a device for sensing a gas according to any of claims 1 to 21.

25. A device for sensing a gas substantially as hereinbefore described with reference to the accompanying drawings.

26. A method of manufacturing a device for sensing a gas substantially as hereinbefore described with reference to the accompanying drawings.

Fig. 1



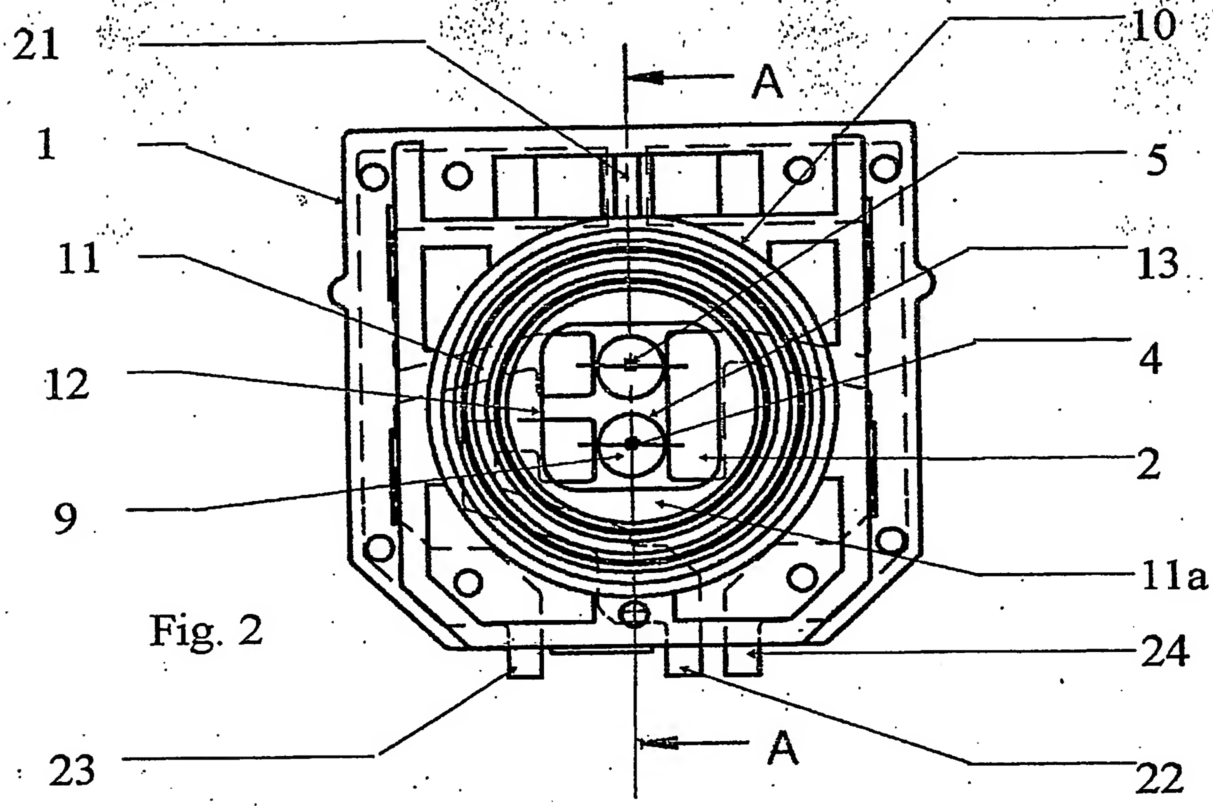
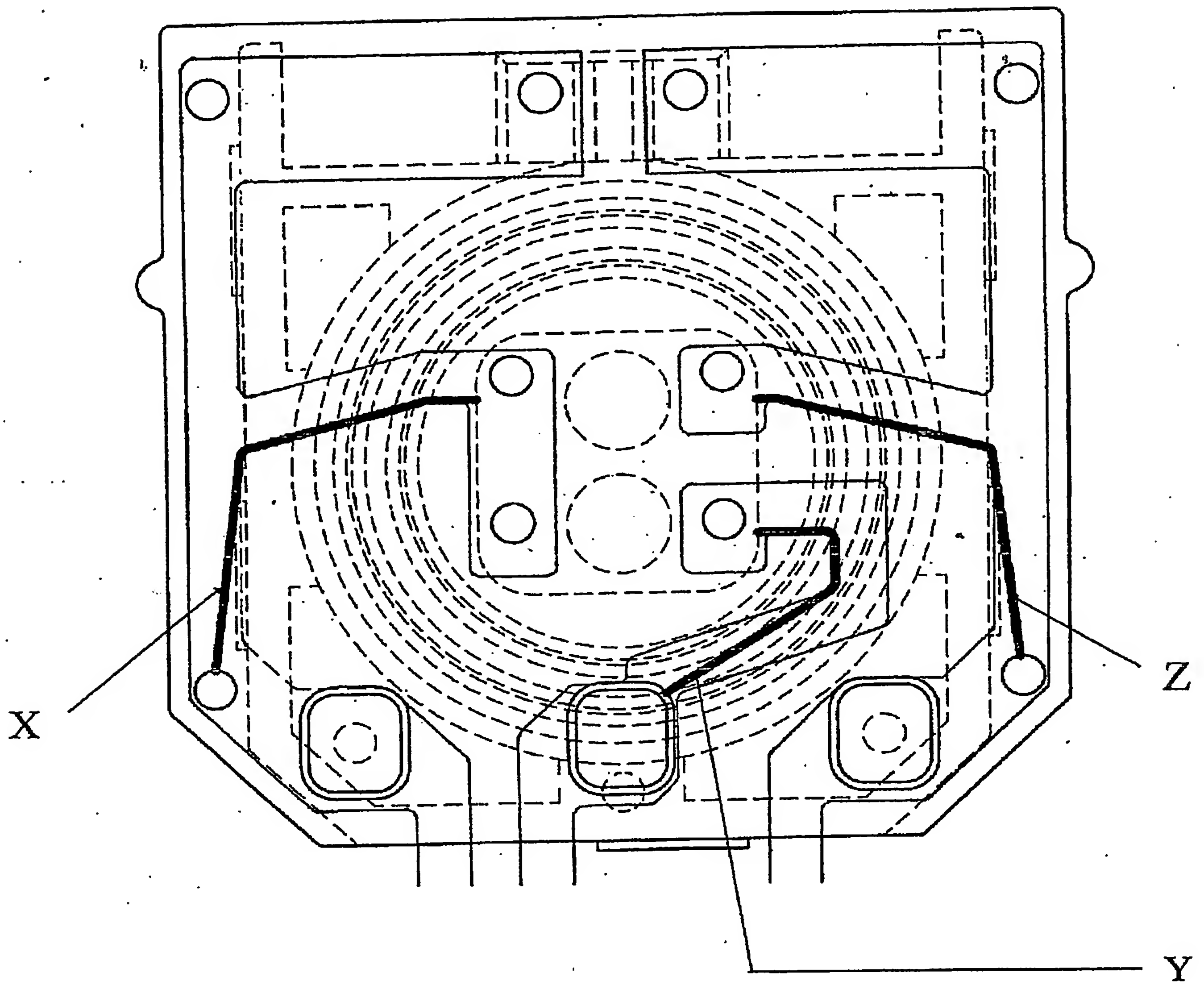


Fig. 2

Fig. 2A



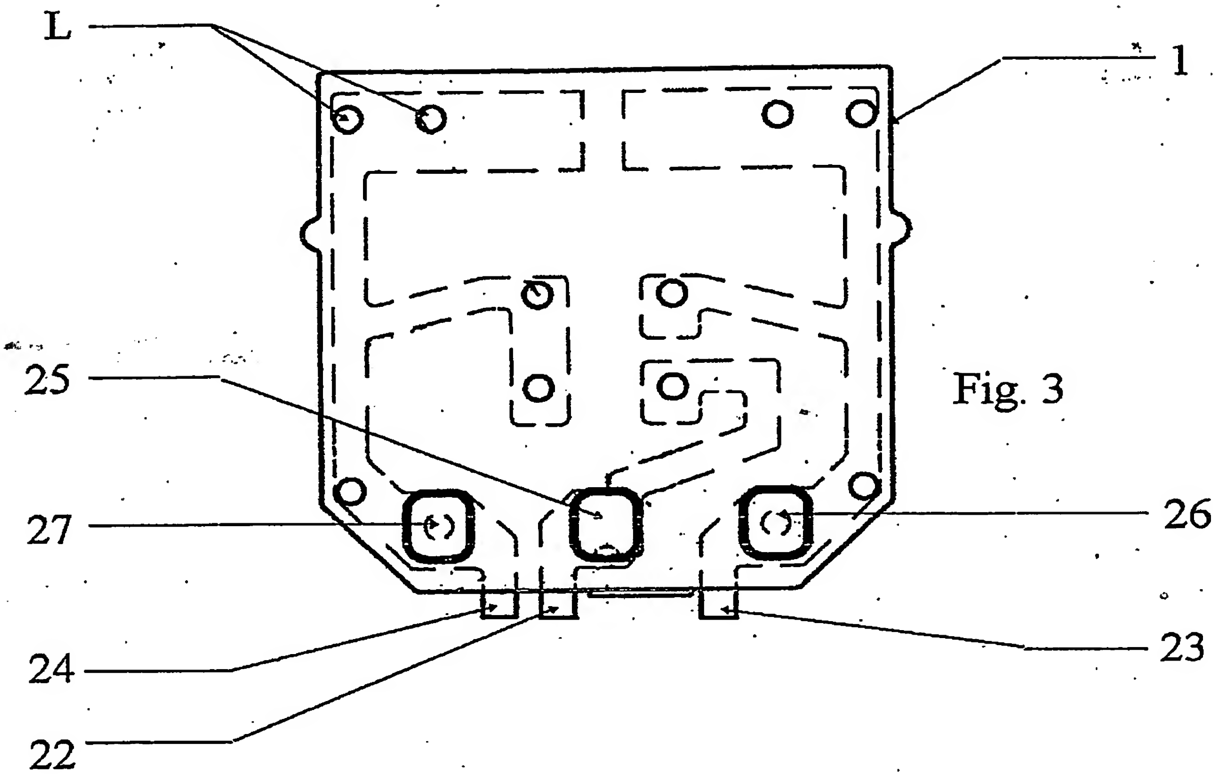


Fig. 3

Fig. 4

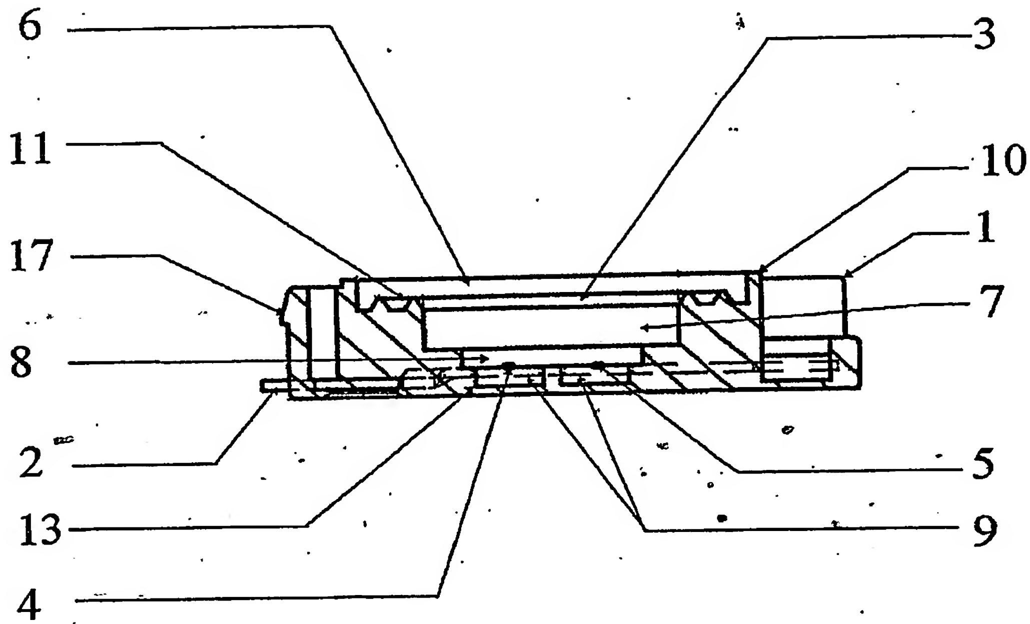


Fig. 5a

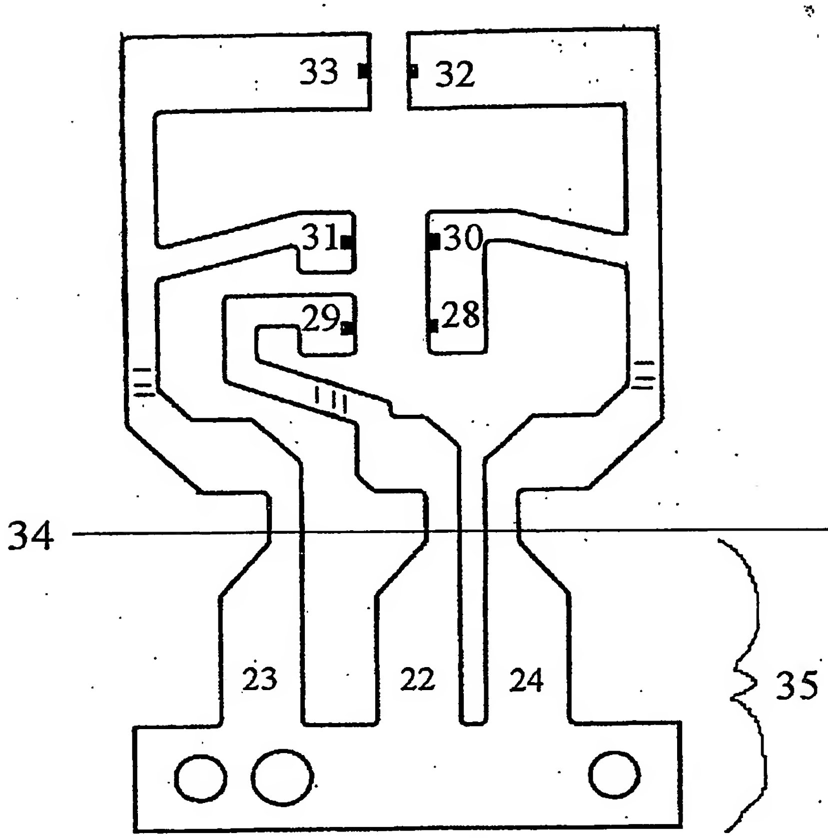
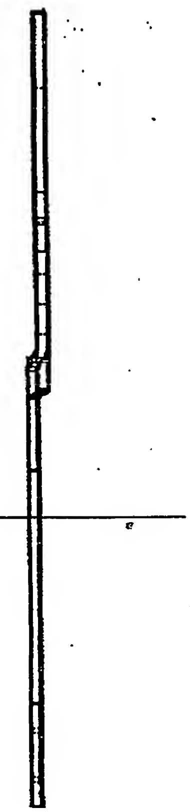


Fig. 5b



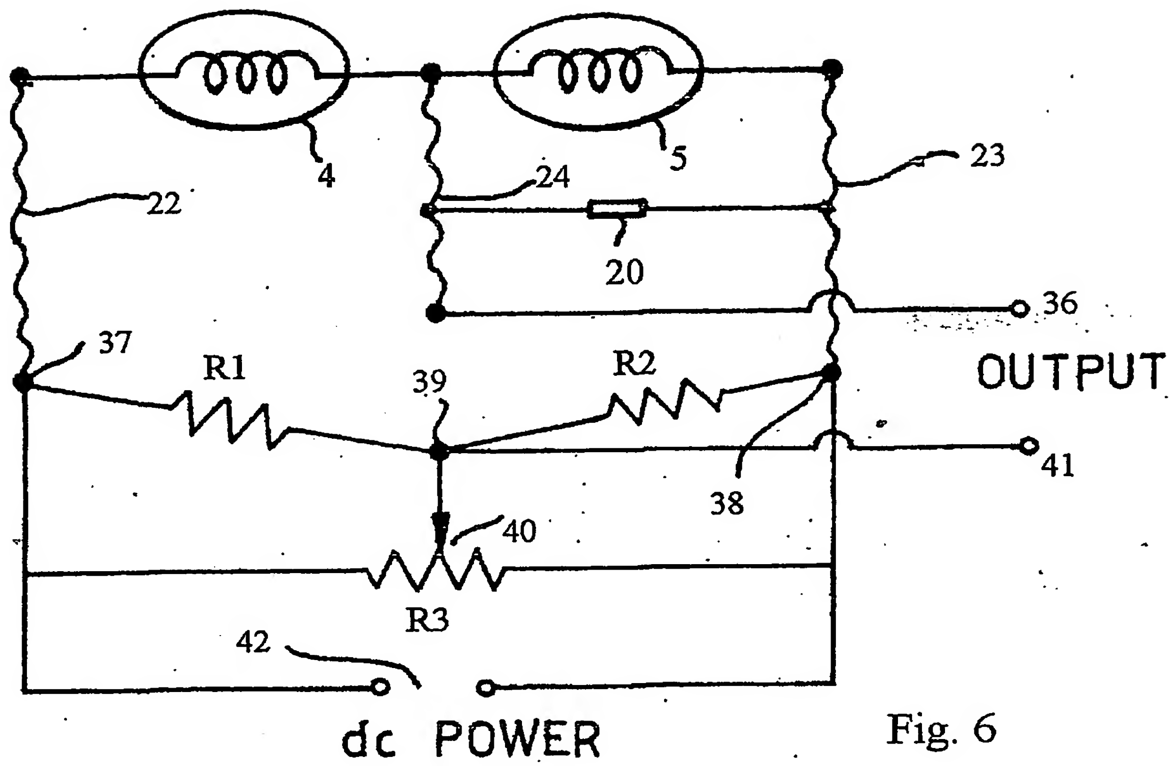


Fig. 6

PCT Application
GB0305126